



Designation: B88 – 20

Standard Specification for Seamless Copper Water Tube¹

This standard is issued under the fixed designation B88; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ε) indicates an editorial change since the last revision or reappraisal.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification establishes the requirements for seamless copper water tube suitable for general plumbing, similar applications for the conveyance of fluids, and commonly used with solder, flared, or compression-type fittings. The type of copper water tube suitable for any particular application is determined by the internal or external fluid pressure, by the installation and service conditions, and by local requirements. Means of joining or bending are also factors which affect the selection of the type of tube to be used.²

NOTE 1—Annealed tube is suitable for use with flared or compression fittings, and with solder-type fittings, provided rounding and sizing of the tube ends is performed where needed.

NOTE 2—Drawn temper tube is suitable for use with solder-type fittings. Types K and L tube, in the drawn temper, are suitable for use with certain types and sizes of compression fittings.

NOTE 3—Fittings used for soldered or brazed connections in plumbing systems are described in ASME B16.18 and ASME B16.22.

1.2 The tube shall be produced from the following coppers, and the manufacturer has the option to supply any one of them, unless otherwise specified.

Copper UNS No.	Previously Used Designation	Description
C12000	DLP	Phosphorus deoxidized, low residual phosphorus
C12200	DHP	Phosphorus deoxidized, high residual phosphorus

1.3 The assembly of copper plumbing or fire sprinkler systems by soldering is described in Practice B828.

1.4 Solders for joining copper potable water or fire sprinkler systems are covered by Specification B32. The requirements for acceptable fluxes for these systems are covered by Specification B813.

¹ This specification is under the jurisdiction of ASTM Committee B05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.04 on Pipe and Tube.

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² The UNS system for copper and copper alloys (see Practice E527) is a simple expansion of the former standard designation system accomplished by the addition of a prefix “C” and a suffix “00.” The suffix is permitted to be used to accommodate composition variations of the base alloy.

1.5 *Units*—The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.5.1 This specification is the companion specification to SI Specification B88M; therefore, no SI equivalents are shown in this specification.

1.6 The following safety hazards caveat pertains only to the test methods portion, Section 16, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards*:³

B32 Specification for Solder Metal

B88M Specification for Seamless Copper Water Tube (Metric)

B153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing

B577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper

B813 Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube

B828 Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings

B846 Terminology for Copper and Copper Alloys

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

- B900 Practice for Packaging of Copper and Copper Alloy Mill Products for U.S. Government Agencies
- B968/B968M Test Method for Flattening of Copper and Copper-Alloy Pipe and Tube
- E8/E8M Test Methods for Tension Testing of Metallic Materials
- E18 Test Methods for Rockwell Hardness of Metallic Materials
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E53 Test Method for Determination of Copper in Unalloyed Copper by Gravimetry
- E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)⁴
- E112 Test Methods for Determining Average Grain Size
- E243 Practice for Electromagnetic (Eddy Current) Examination of Copper and Copper-Alloy Tubes
- E255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition
- E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

2.3 ASME Standards:

- ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings⁵
- ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings⁵

⁴ The last approved version of this historical standard is referenced on www.astm.org.

⁵ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

3. Terminology

3.1 *Definitions*:—For definitions of terms related to copper and copper alloys, refer to Terminology B846.

4. Ordering Information

4.1 Include the following specified choices when placing orders under this specification, as applicable.

- 4.1.1 ASTM designation and year of issue (for example, B88 – 03);
- 4.1.2 Copper [Alloy] UNS No. (or other internationally recognized alloy) designation (not necessary unless a specific copper is desired);
- 4.1.3 Nominal or standard size (Column 1 of Table 1) and whether Type K, L, or M (Sections 3 and 12);
- 4.1.4 Temper (Section 7);
- 4.1.5 Length (see 12.5);
- 4.1.6 How furnished: straight lengths or coils; and
- 4.1.7 Quantity (pieces) of each size and type.
- 4.1.8 If product is purchased for agencies of the U.S. Government, it shall conform to the Supplementary Requirements as defined herein when specified in the contract or purchase order.

4.2 The following options are available and shall be specified at the time of the order, when required:

- 4.2.1 Expansion of chemical analysis (see 6.2);
- 4.2.2 Tensile test;
- 4.2.3 Grain size determination (Section 8);
- 4.2.4 Hardness test (Section 9);
- 4.2.5 Expansion test (10.1);
- 4.2.6 Flattening test (10.2);

TABLE 1 Dimensions, Weights, and Tolerances in Diameter and Wall Thickness for Nominal or Standard Copper Water Tube Sizes
(All tolerances are plus and minus except as otherwise indicated)

Nominal or Standard Size, in.	Outside Diameter, in.	Average Outside Diameter ^A Tolerance, in.		Wall Thickness and Tolerances, in.						Theoretical Weight, lb/ft		
		Annealed	Drawn	Type K		Type L		Type M		Type K	Type L	Type M
				Wall Thickness	Tolerance ^B	Wall Thickness	Tolerance ^B	Wall Thickness	Tolerance ^B			
1/4	0.375	0.002	0.001	0.035	0.0035	0.030	0.003	^C	^C	0.145	0.126	^C
3/8	0.500	0.0025	0.001	0.049	0.005	0.035	0.004	0.025	0.002	0.269	0.198	0.145
1/2	0.625	0.0025	0.001	0.049	0.005	0.040	0.004	0.028	0.003	0.344	0.285	0.204
5/8	0.750	0.0025	0.001	0.049	0.005	0.042	0.004	^C	^C	0.418	0.362	^C
3/4	0.875	0.003	0.001	0.065	0.006	0.045	0.004	0.032	0.003	0.641	0.455	0.328
1	1.125	0.0035	0.0015	0.065	0.006	0.050	0.005	0.035	0.004	0.839	0.655	0.465
1 1/4	1.375	0.004	0.0015	0.065	0.006	0.055	0.006	0.042	0.004	1.04	0.884	0.682
1 1/2	1.625	0.0045	0.002	0.072	0.007	0.060	0.006	0.049	0.005	1.36	1.14	0.940
2	2.125	0.005	0.002	0.083	0.008	0.070	0.007	0.058	0.006	2.06	1.75	1.46
2 1/2	2.625	0.005	0.002	0.095	0.010	0.080	0.008	0.065	0.006	2.93	2.48	2.03
3	3.125	0.005	0.002	0.109	0.011	0.090	0.009	0.072	0.007	4.00	3.33	2.68
3 1/2	3.625	0.005	0.002	0.120	0.012	0.100	0.010	0.083	0.008	5.12	4.29	3.58
4	4.125	0.005	0.002	0.134	0.013	0.110	0.011	0.095	0.010	6.51	5.38	4.66
5	5.125	0.005	0.002	0.160	0.016	0.125	0.012	0.109	0.011	9.67	7.61	6.66
6	6.125	0.005	0.002	0.192	0.019	0.140	0.014	0.122	0.012	13.9	10.2	8.92
8	8.125	0.006	+ 0.002 -0.004	0.271	0.027	0.200	0.020	0.170	0.017	25.9	19.3	16.5
10	10.125	0.008	+ 0.002 -0.006	0.338	0.034	0.250	0.025	0.212	0.021	40.3	30.1	25.6
12	12.125	0.008	+ 0.002 -0.006	0.405	0.040	0.280	0.028	0.254	0.025	57.8	40.4	36.7

^A The average outside diameter of a tube is the average of the maximum and minimum outside diameter, as determined at any one cross section of the tube.

^B Maximum deviation at any one point.

^C Indicates that the material is not generally available or that no tolerance has been established.

- 4.2.7 Microscopical Examination for Hydrogen Embrittlement, Procedure B (10.3.1.1);
- 4.2.8 Heat identification or traceability (5.1.2);
- 4.2.9 Certification;
- 4.2.10 Mill Test Report; and
- 4.2.11 Product specification number to be shown on package (see 23.2).

5. Materials and Manufacture

5.1 Materials:

5.1.1 The material of manufacture shall be a form of such purity and soundness as to be suitable for processing into the products prescribed herein.

5.1.2 When specified in the contract or purchase order that heat identification or traceability is required, the purchaser shall specify the details desired.

NOTE 4—Because of the discontinuous nature of the processing of castings into wrought products, it is not practical to identify specific casting analysis with a specific quantity of finished material.

5.2 Manufacturer:

5.2.1 The product shall be manufactured by such hot-working, cold-working, and annealing processes as to produce a uniform wrought structure in the finished product.

5.2.2 The product shall be hot- or cold-worked to the finished size and subsequently annealed, when required, to meet the temper properties specified.

5.2.3 Tube, when furnished in coils, shall be annealed after coiling.

5.2.4 Tube, when furnished in straight lengths, shall normally be in the drawn temper. Upon agreement between the manufacturer or supplier and the purchaser, the manufacturer shall have the option to supply annealed straight length tubing.

6. Chemical Composition

6.1 The material shall conform to the chemical composition requirements in Table 2 for the copper [alloy] UNS No. designation if specified in the ordering information.

6.2 These composition limits do not preclude the presence of other elements. By agreement between the manufacturer and the purchaser, limits may be established and analysis required for unnamed elements.

7. Temper

7.1 The standard tempers for products described in this specification are given in Table 3.

7.1.1 Annealed tempers O60, and O50.

7.1.2 Drawn temper H58.

TABLE 2 Chemical Composition—Weight %

Element	Copper UNS No.	
	C12000	C12200
Copper, ^A min	99.90	99.9
Phosphorus	0.004–0.012	0.015–0.040

^A Copper + silver.

8. Grain Size for Annealed Tempers

8.1 When specified in the contract or purchase order, the annealed products furnished under this specification shall conform to the grain requirements prescribed in Table 3.

8.2 Acceptance or rejection based upon grain size shall depend on the average grain size of a test specimen and shall be within the limits prescribed in Table 3 when determined in accordance with Test Methods E112.

9. Mechanical Property Requirements

9.1 Tensile Strength Requirements:

9.1.1 The product furnished under this specification shall conform to the tensile requirements prescribed in Table 3, when tested in accordance with Test Methods E8/E8M. Actual testing need not be performed unless specified at time of order placement. Acceptance or rejection based upon mechanical properties shall depend on tensile strength.

9.2 Rockwell Hardness Requirement:

9.2.1 When specified in the contract or purchase order, the product shall conform to the Rockwell hardness requirement prescribed in Table 3, when tested in accordance with Test Methods E18.

10. Performance Requirements

10.1 Expansion Test:

10.1.1 When specified in the contract or purchase order, tube furnished annealed (O) shall be capable of expansion in accordance with Test Method B153 to the following extent:

Nominal or Standard Size, in.	Expansion of Outside Diameter, %
5/8 and under	40
Over 5/8	30

The expanded tube shall show no cracking or other defects visible to the unaided eye.

10.2 Flattening Test:

10.2.1 When specified in the contract or purchase order, the flattening test in accordance with Test Method B968/B968M shall be performed. As an alternative to the expansion test for tube standard sizes 4 in. and over in the annealed condition, a section 4 in. in length shall be cut from the end of one of the lengths for a flattening test. This 4 in. test specimen shall be flattened so that a gage set at three times the wall thickness will pass over the tube freely throughout the flattened part. The tube so tested shall develop no cracks or flaws visible to the unaided eye as a result of this test. In making the flattening test the elements shall be slowly flattened by one stroke of the press.

10.2.1.1 During inspection, the flattened areas of the test specimen shall be free of defects, but blemishes of a nature that do not interfere with the intended application are acceptable.

10.3 Microscopical Examination for Susceptibility to Hydrogen Embrittlement:

10.3.1 Tubes furnished in Copper UNS No. C12000 shall be essentially free of cuprous oxide as determined by Procedure A of Test Methods B577. When Copper UNS No. C12200 is supplied, examination is not required. In case of a dispute, Procedure C of Test Methods B577 shall be used as the referee method.

TABLE 3 Mechanical Property Requirements

Temper Designation		Form	Rockwell Hardness ^A		Tensile Strength, min, ksi ^B	Average Grain Size, mm
Code	Name		Scale	Value		
O60	Soft Anneal	straight lengths/coils	F	50 max	30	0.040 min
O50	Light Anneal	straight lengths/coils	F	55 max	30	0.040 max
H58	drawn	drawn	30 T	30 min	36	...

^A Rockwell hardness tests shall be made on the inside surfaces of the tube. When suitable equipment is not available for determining the specified Rockwell hardness, other Rockwell scales and values shall be specified subject to agreement between the purchaser and the supplier.

^B ksi = 1000 psi.

10.3.1.1 Tubes furnished in all coppers shall be capable of passing the embrittlement test specified in Procedure B of Test Methods B577. In case of a dispute, Procedure C of Test Methods B577 shall be used as the referee method.

11. Other Requirements

11.1 Nondestructive Testing Requirements:

11.1.1 Each tube up to and including 3/8 in. in outside diameter shall be subjected to an eddy-current test. Testing shall follow the procedures of Practice E243, except for the determination of “end effect.” Tubes shall be passed through an eddy-current test unit adjusted to provide information on the suitability of the tube for the intended application.

11.1.1.1 Notch-depth standards, rounded to the nearest 0.001 in., shall be 22 % of the wall thickness. The notch-depth tolerance shall be ±0.0005 in. Alternatively, at the option of the manufacturer using speed insensitive eddy-current units that are equipped to select a fraction of the maximum unbalance signal, the following percent maximum unbalance signals shall be used:

Nominal or Standard Tube Size, in.	Unbalance Signal Magnitude, max %
Up to 3/8, incl	0.2
1/2 to 2, incl	0.3
Over 2 to 3, incl	0.4

11.1.1.2 Tubes that do not actuate the signaling device of the eddy-current testers shall be considered as conforming to the requirements of this test. Tubes with discontinuities indicated by the testing unit shall, at the option of the manufacturer, be reexamined or retested to determine whether the discontinuity is cause for rejection. Signals that are found to have been caused by minor mechanical damage, soil, or moisture, shall not be cause for rejection of the tubes provided the tube dimensions are still within prescribed limits and the tube is suitable for its intended application.

11.1.2 Tube made to this specification shall be capable of withstanding the pressure test of 11.1.2.1 or 11.1.2.2. On subsequent testing by the purchaser, failure to meet the requirements of 11.1.2.1 or 11.1.2.2 are grounds for rejection of the material by the purchaser.

11.1.2.1 The tube shall stand, without showing evidence of leakage, an internal hydrostatic pressure sufficient to subject the material to a fiber stress of 6000 psi, calculated from the following equation for thin hollow cylinders under tension:

$$P = 2 St / (D - 0.8t) \tag{1}$$

where:

P = hydrostatic pressure, psi;

t = wall thickness, in.;

D = outside diameter of the tube, in.; and

S = allowable stress of the material, psi.

11.1.2.2 The tube shall stand an internal air pressure of 60 psig for 5 s without showing evidence of leakage. The test method used shall permit easy visual detection of any leakage, such as by having the tube under water or by the pressure differential method.

12. Dimensions, Mass, and Permissible Variation

12.1 For the purpose of determining conformance with the dimensional requirements prescribed in this specification, any measured value outside the specified limiting values for any dimension shall make the tube subject to rejection at the option of the purchaser.

12.2 Standard Dimensions, Wall Thickness, and Diameter Tolerances—The standard dimensions, wall thickness, and diameter tolerances shall be in accordance with Table 1.

12.3 Mass—For purposes of calculating weights, cross sections, and so forth, the density of the copper shall be taken as 0.323 lb/in.³ The theoretical weight per foot is given in Table 1.

12.4 Roundness—For drawn unannealed tube in straight lengths, the roundness tolerance shall be as prescribed in Table 4. The deviation from roundness is measured as the difference between major and minor diameters as determined at any one cross section of the tube. No roundness tolerance has been established for annealed tube in straight lengths or for tubes furnished in coils.

12.5 Lengths and Tolerances:

12.5.1 Standard Lengths and Tolerances—The standard lengths and tolerances shall be as specified in Table 5.

12.5.2 Tube supplied in other than standard lengths and tolerances shall be in accordance with requirements established by agreement between the manufacturer or supplier and the purchaser.

12.6 Squareness of Cut—For tube in straight lengths, the departure from squareness of the end of any tube shall not

TABLE 4 Roundness Tolerance

t/D (Ratio of Wall Thickness to Outside Diameter)	Roundness Tolerance % of Outside Diameter (Expressed to Nearest 0.001 in.)
0.01 to 0.03, incl	1.5
Over 0.03 to 0.05, incl	1.0
Over 0.05 to 0.10, incl	0.8

TABLE 5 Standard Lengths and Tolerances

Nominal or Standard Size, in.	Type	Standard Length, ft	Tolerance (All Plus)
Tubes Furnished in Straight Lengths			
Up to 8, incl	K, L, M	10 and 20	1 in.
10	L, M	20	1 in.
10	K	18	1 in.
12	M	20	1 in.
12	L	18	1 in.
12	K	12	1 in.
Tubes Furnished in Coils			
Up to 1, incl	K, L	60 and 100	2 ft
1¼ and 1½	K, L	60	2 ft
2	K, L	40 and 60	1 ft

exceed more than 0.010 in./in. of outside diameter for tube up to and including ½ in. standard size; and not more than 0.016 in./in. of outside diameter for tube larger than ½-in. standard size.

13. Workmanship, Finish, and Appearance

13.1 The product shall be free of defects, but blemishes of a nature that do not interfere with the intended application are acceptable.

14. Sampling

14.1 Sampling—The lot, size, portion size, and selection of sample pieces shall be as follows:

14.1.1 Lot Size—The lot size shall be 5000 lb or fraction thereof.

14.1.2 Sample pieces shall be taken for test purposes from each lot according to the following schedule:

Number of Pieces in Lot	Number of Sample Pieces to be Taken ^A
1 to 50	1
51 to 200	2
201 to 1500	3
Over 1500	0.2 % of total number of pieces in lot but not more than 10 sample pieces

^A Each sample piece shall be taken from a separate tube.

15. Number of Tests and Retests

15.1 Tests:

15.1.1 Chemical Analysis—Samples for chemical analysis shall be taken in accordance with Practice E255. Drillings, millings, and so forth shall be taken in approximately equal weight from each of the sample pieces selected in accordance with 14.1 and combined into one composite sample. The minimum weight of the composite sample that is to be divided into three equal parts shall be 150 g.

15.1.1.1 Instead of sampling in accordance with Practice E255, the manufacturer shall have the option of determining conformance to chemical composition as follows: Conformance shall be determined by the manufacturer by analyzing samples taken at the time the castings are poured or samples taken from the semi-finished product. If the manufacturer determines the chemical composition of the material during the course of manufacture, he shall not be required to sample and

analyze the finished product. The number of samples taken for determination of chemical composition shall be as follows:

15.1.1.2 When samples are taken at the time the castings are poured, at least one sample shall be taken for each group of castings poured simultaneously from the same source of molten metal.

15.1.1.3 When samples are taken from the semi-finished product, a sample shall be taken to represent each 10 000 lb or fraction thereof, except that not more than one sample shall be required per piece.

15.1.2 Mechanical Tests—For the mechanical tests, a specimen shall be taken from each of the sample pieces selected in accordance with 14.1. The required mechanical test shall be made on each of the specimens so selected. The value for the Rockwell hardness number of each specimen shall be established by taking the arithmetical average of at least three readings.

15.1.3 Microscopical Examination—One specimen shall be examined from each of the sample pieces selected in accordance with 14.1.

15.1.3.1 In the case of tube furnished in coils, a length sufficient for all necessary tests shall be cut from each coil selected for the purpose of tests. The remaining portion of these coils shall be included in the shipment, and the permissible variations in length of such coils shall be waived.

15.2 Retests:

15.2.1 If any test specimen shows defective machining or develops flaws, it shall be discarded and another specimen substituted.

15.2.2 If the results of any test for microscopical examination or mechanical properties fail to meet the specified requirements, two additional specimens shall be taken from different sample pieces and tested. The results of the tests on both of these specimens shall meet the specified requirements. Failure of more than one specimen to meet the specified requirements for a particular property shall be the cause for rejection of the entire lot.

15.2.3 If the chemical analysis fails to conform to the specified limits, analysis shall be made on a new composite sample prepared from additional pieces selected in accordance with 14.1. The results of this retest shall comply with the specified requirements.

16. Test Methods

16.1 Chemical Analyses:

16.1.1 In cases of disagreement, test methods for chemical analysis shall be subject to agreement between the manufacturer or supplier and the purchaser. The following table is a list of published methods, some of which may no longer be viable, which along with other not listed, may be used, subject to agreement:

Element	ASTM Test Method
Copper	E53
Phosphorous	E62

16.1.2 Test method(s) to be followed for the determination of element(s) resulting from contractual or purchase order agreement shall be as agreed upon between the manufacturer or supplier and purchaser.